A quantum accurate waveform synthesizer as a voltage reference for an electronic primary thermometer ALESSIO POLLAROLO, SAMUEL BENZ, HORST ROGALLA, PAUL DRESSELHAUS, NIST — We are using a quantum voltage noise source (QVNS) for use as an intrinsically accurate voltage reference for a new type of electronic temperature standard. In Johnson Noise Thermometry (JNT) the noise of a resistor is used to measure temperature or Boltzmann’s constant $k$, because the Nyquist equation $<V^2> = 4kTR\Delta f$ shows that the power spectral density $<V^2>$ is proportional to $k$, temperature $T$, resistance $R$ and measurement bandwidth $\Delta f$. The QVNS is a digital to analog converter used to synthesize a voltage waveform that resembles pseudo-random noise comparable in amplitude to the resistor noise. The signal generated is a frequency comb of harmonics tones that are equally spaced in frequency, all having identical amplitudes but random phases. The QVNS is an array of superconducting Josephson junctions that are biased with a pulsed waveform clocked at 10 GHz. The accuracy of the voltage waveform derives from the identical voltage pulses produced by each junction that are perfectly quantized because their time-integrals are always equal to flux quantum $h/2e$. The time-dependent output voltage waveform is determined by the number of pulses and their density in time. The measurement electronics exploits cross-correlation techniques to reduce the uncorrelated measurement noise so as to reveal the resistor noise, both of which are on the order of $2 \text{nV}\sqrt{\text{Hz}}$. With this technique we have measured $k$ with an uncertainty of about one part in $10^5$, which we hope to improve by another order of magnitude with further research.

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Date submitted: 15 Nov 2013

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